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CALENDAR REFORM FROM AN ASTRONOMER'S VIEWPOINT*

BY ROBERT G. AITKEN†

OUR present calendar, particularly in its role as a social and economic timekeeper, is sadly out of step with our vaunted "practical" civilization. This has been pointed out many times, and its defects need not be listed again. The plan of The World Calendar has been widely circulated. It is a scientific document; it is simple and perpetual; it meets all social and economical as well as astronomical requirements. I see no good reason why it should not be adopted.

Astronomers, with their eyes on the whole universe, have a uniquely impartial viewpoint from which to consider calendar problems. Think of the tribulations of calendar makers on the planet Jupiter. Not only are there about 10,500 days in the year, but the number of days probably varies with the latitude and at the equator may be fully 90 greater than in high north and south latitudes.

Even with the inhabitants of Mars the calendar problem is bad enough. The planet's year has 668.6 days. Three different schemes for a Martian calendar have been suggested. The inhabitants, if any, might have four years of 669 days each, followed by one of only 667 days; or they might have four years of 668 days each, followed by one with 671 days. By either plan they would have 3,343 days in five years, which is what the actual rotation and revolution periods require. But a third alternative is probably more practical—to have the Martian years run alternately 668 and 669 days, and then insert an extra leap-day every tenth year to care for the odd one-tenth of a day. This would keep dates in step with the seasons for more than 10,000 years.

The year on Mars might well be divided into quarters of 167 days each. There is nothing on Mars that corresponds exactly to the Earth's lunar period (which gives rise to the monthly and weekly subdivisions of the Earthly calendar). Mars has two moons, the outer of which makes one complete revolution in about 1¼ of our days, while the inner one

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†Deceased Oct. 29, 1951; see obituary, *R.A.S.C., Jour.*, vol. 46, p. 28, 1952.

revolves nearly four times as fast. A Martian calendar might well provide a year with 16 months of 42 days each, and these months might be further subdivided for convenience into six weeks each.

A man from Mars, if he came to Earth and examined our hodge-podge calendar, would be likely to express his surprise that the human race, which prides itself upon its progressiveness, had so long been content to put up with this situation, and that it should be so slow and hesitant about adopting the revision proposed by The World Calendar Association, a revision that would so obviously improve and simplify—particularly since the adoption of the new system could be effected with so little inconvenience to anyone. He would listen with impatience to any explanation about the power of tradition and the reluctance of the conservative element to give up an old custom or tradition in favour of a new one, even though the new one offers definite advantages. This, he would contend, is unreasonable. It is all right to "hold fast to that which is good," but why should anybody hold fast to something that is not so good and that can so easily be made better?

Of course it would be most convenient if our year contained an exact number of days, and if that number were exactly divisible both by 7 and 12. But Dame Nature, if she be the responsible party, has been culpably indifferent to commensurability in the rotation periods and revolution periods of the Earth and of all the other planets. Happily this is of no consequence except for Mars and the Earth, for as we know, the other planets are uninhabitable, or at least uninhabited.

Improvement of the Earthly calendar has been a live subject of discussion from prehistoric times. It all began with that period in man's climb upward toward what we are pleased to call civilization, when he forsook his nomad wanderings and began the practice of agriculture, and the building of more or less organized communities. Earlier he had felt no special need for a definite standard of reference to keep account of his business transactions and sundry appointments. When that need did arise, he found his standard on hand in the apparent motions of the sun and moon.

Long centuries before, when men were still nomads, the wiseacres of those who roamed the river lands of Egypt and Mesopotamia had marked the courses of the sun and moon among the stars. They had noted that it took the moon about 28 to 29 days to run through its cycle of phases, and the sun about 365 days (or about 12 lunar changes of phase) to pass from vernal equinox back to vernal equinox again. They had also noted that the moon needed about 7 days to pass from one phase to another, and they gave each day of the seven a distinctive name—Sun-day, Moon-day, or names drawn from the tribe's earlier myths and legends.

Having now the approximate length of the year and of the month, the next problem was to combine them in one cycle that would repeat

itself endlessly. Efforts to solve that problem encountered a fact that baffled calendar makers through the centuries: the lengths of the month and the year, expressed in solar days, are incommensurable quantities and nothing that man can do will alter the fact. The astronomer cannot help, he cannot change the velocities or orbits of the celestial bodies, he can only measure and compute. This he has done with ever-increasing accuracy, until the precision of his data far exceeds the needs of the calendar maker. For the latter's purpose it suffices to know that the time from one equinoctial passage of the sun to the next (the so-called "tropical" year) equals 365.242 days, and that the length of the ordinary month from New Moon round to New Moon again is 29.531 solar days.

A good calendar, however, is one in which the tabulated date of the vernal equinox falls invariably on the day when the sun reaches the true equinoctial point in the heavens. It was found that this could be accomplished reasonably well for a short period by the use of intercalary days. In fact, the whole history of the calendar down to the middle of the first century B.C. (whether we follow the Mesopotamian or the Egyptian efforts to establish a sound system) is the story of more or less successful intercalation. The results were mostly lamentably unsuccessful; so that when Julius Caesar came into power, the computed date of the equinox was 80 or 90 days ahead of the true date, and the whole calendar was a mess.

Caesar decided to scrap it and start anew. To this end he called upon an expert for advice, as other rulers have done before and since. Caesar differed from others, however, in that when Sosigenes, the expert, gave his advice Caesar studied the recommendations carefully and then acted upon them! That indeed is a course which may well be urged to some of the great powers and leaders of the present day.

The Sosigenes recommendations and instructions were drastic, it is true, and might have given pause to a lesser man than Julius. But drastic action was, so to speak, Caesar's long suit, and once he had satisfied himself that the cards were genuine, he played his hand masterfully. As Sosigenes had recommended, he decreed that the calendar's vernal equinox should always fall on 21 March, and that the length of the year should be precisely 365¼ days. Then, to combine these two decrees successfully, he adopted what Sir John Herschel describes as "Sosigenes' neat contrivance" of having two artificial years—one with a length of 365 days, to hold for three years in succession, and the other of 366 days, to apply to the fourth year and bring the average of the four to 365¼ days.

What Caesar said became, *ipso facto*, law. The new calendar went into effect as ordained, throughout the Roman Empire. Unfortunately, Julius himself was assassinated about a year later, and the men to whom the care of the calendar was then entrusted did not know what it was

all about. They misread the rules, for they could not count, they could only add. They therefore began adding one day in three, instead of one in four years. Their error was eventually brought to the attention of Augustus, who also being an Emperor, rectified matters by a simple order. Thus remedied, the Julian Calendar remained in force until the days of Pope Gregory XIII.

It might still be in force except for the fact that heavenly bodies refuse to obey even a Caesar. The sun insisted on coming to the vernal equinoctial point at regular intervals of 365.242 days, instead of precisely 365.25 days, as ordained. The difference may have seemed to Caesar as negligibly slight, but it was cumulative and by the 16th century it had amounted to ten days, an "intolerable error" to the leaders of thought in those opening days of new-born science.

They began to petition the rulers of the Catholic Church, the only power whose orders ran across national boundary lines, to correct it, but did not succeed until 1582. Then Pope Gregory ordained that the last day on which the Julian Calendar might be used officially in his jurisdiction would be 5 October 1582; the day following would be known as 15 October, the first official date of the new Gregorian Calendar. This would set the calendar straight; and to keep it so, centennial years thereafter were to be leap years only if their numerical figures were divisible by 400. Thus 1900 was not a leap year, 2000 will be. With these changes the calendar would continue to tell the truth for more than 3,000 years.

Slight, relatively speaking, as these proposed changes were, they raised a violent outcry throughout Europe. It soon subsided in Catholic countries, but held on long in lands that did not owe allegiance to the Pope. In England and the American colonies, it did not disappear until after an Act of Parliament decreed that 2 September 1752, should be the last date for official use of the Julian Calendar and should be followed by 14 September of the Gregorian Calendar.

For 170 years then the champions of the Julian and Gregorian Calendars had disputed and argued, to the annoyance of later chronologists. Advocates of both systems were forced to adopt the custom of adding O.S. ("Old Style," for Julian) or N.S. ("New Style," for Gregorian) to dated letters and documents.

If it took 170 years and more to get the simple and obviously meritorious Gregorian reform adopted internationally, how long will it take to enact the equally simple and worthwhile World Calendar? Let us hope we have grown wiser with the passing years and can attend to this important matter with speed and unity. Already 117 years have passed since the Italian Abbé Mastrofini initiated modern calendar reform. Surely we should proceed in this important matter with speed and unity.

ON THE SPECTRUM OF THE GREEN FLASH AT SUNSET*

By T. S. Jacobsen

ABSTRACT

A microphotometric comparison was made of the intensity distribution in five green-flash and six low-sun diffraction camera spectra recorded on a colour movie film. The green flash was shown to be accompanied by an intensification of green light relative both to other colours in its own spectrum and to the green present in the low-sun spectrum taken 29 seconds earlier.

On March 30, 1950, during a visit to the Hawaiian Islands, Mrs. Patsy V. Sinkey and Mrs. Florence A. Grondel, both of Seattle, Washington, took colour movies of the spectrum of the green flash at sunset. Since these films are probably the first ever to show the spectrum of the flash, they will be described in the following article, and a study of the intensity distribution in the spectrum will be made.

The films were taken on Kodachrome film with a 63 mm. coated Eastman anastigmat camera lens of 12.6 cm. focal length. The camera speed was eight frames per second, giving an exposure time of approximately 1/15 second on each picture. The observers were stationed at Waikai Beach on the west coast of Oahu Island, at a slight elevation of about 5 feet above sea level. The camera was set up with a sweeping view of the western ocean horizon, and in the foreground was a flat, dark-coloured sandy beach at an angle of depression from the horizon of from 30 to 35 degrees. The spectrum was obtained by the use of a transmission diffraction grating, a replica of a Rowland grating of 25,110 lines to the inch, lent by the Astronomy Department of the University of Washington. The grating was mounted, lines horizontal, directly in front of the camera lens at right angles to the optical axis. The first order spectrum was centred on the the film by lining up the sun in azimuth, then tilting the camera and grating vertically downward by about 33 degrees. Due to the restricted field of the camera lens, the direct solar image was then not recorded on the film. Exposures with the solar image centred were taken some 40 seconds before the exposures on the spectrum. When the sun's upper limb was at an apparent elevation of 1.5 degrees, as measured subsequently on the films, Mrs. Sinkey began an exposure of a few seconds on the sun, with the camera running at a speed of sixteen frames a second. Then, with the exposure continuing, she followed down the light wake of the sun on the water by gradually tilting the grating camera vertically downward until the spectrum, as seen in the finder, appeared centred on a mark made in the smooth dark

*Contribution from the Dominion Astrophysical Observatory, No. 26.

sand of the beach. This operation was repeated six times at convenient intervals, the last two times with a camera speed of only eight frames a second, until total disappearance of the direct solar image below the apparent horizon. By the time the last few frames were being exposed the sun's image had shrunk to a narrow golden line. At this time Mrs. Grondel, who had for some time previously been observing the sunset forms intermittently without optical aid, noticed a naked-eye green flash of moderate intensity and of approximately one-half second duration, a low flash on the extreme top of the sun. For two or three seconds before the flash became visible to the naked eye, there must have been visible in a telescope of moderate power the development stage of the flash, in which two short green horizontal lines form on the horizon at the ends of the disappearing solar segment and gradually approach one another along the horizon. The flash would occur when these green regions met at the exact point of sunset. The spectrum of the sunlight during this development stage and during the flash was photographed on the last 25 frames of film. The present article describes the results of a study of the spectrum during a flash, and presents a comparison of this spectrum with that of the very low sun immediately preceding the development stage of the flash.

The Observational Material

All photographs of the setting sun are in excellent focus and show the ocean horizon and the solar disk as well as three fairly stationary cloud edges and two inversion layers at measured apparent average elevations above the ocean horizon of 68.4, 57.8, 27.3, 7.9, and 1.3 minutes of arc respectively. The measurements were made by means of a Gaertner measuring machine. The scale value was found from the apparent horizontal diameter of the sun's disk, 32 minutes of arc, as measured on the first frame of series 1, at an altitude of 75 minutes above the apparent sea horizon. At the end of the sixth and last series the sun set, not on the sea horizon, but on the lower inversion layer. All subsequent values of altitudes will therefore be quoted as measured from this origin, situated 1.3 minutes above the sea horizon. A very satisfactory time scale was set up by counting the frames on the film and measuring the altitudes of the sun's upper limb. As an aid to accuracy, four features of each image were measured in both vertical and horizontal position, a green filter being interposed between the eye and the micrometer. The use of the filter generally sharpened the outlines, but whenever they were sharp in yellow and green light, their shapes and sizes were identical with and without the filter. A large-scale outline of the solar disk was drawn and the areas of the images at various stages of setting were measured by a planimeter. The measured areas are plotted in figure 1

against the corresponding time interval before setting. Assuming that the intensity of residual sunlight is either proportional to, or decreases more quickly than, the area of the visible disk, an upper limit can be assigned to the ratio between the intensities of illumination at any two moments in the time series from the ratio of the ordinates of the curve at the moments in question.

Only one series each of low-sun spectra and green-flash spectra at altitudes of 4 and 0.9 minutes respectively showed sufficient purity of spectrum

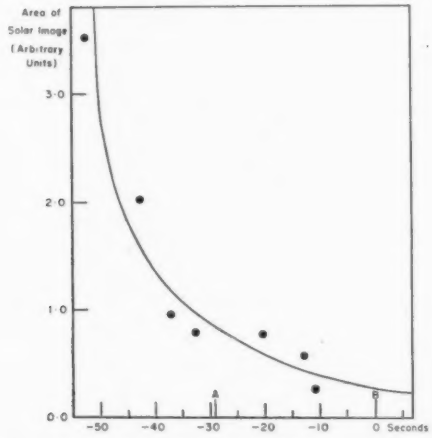

FIG. 1—Areas of direct solar images. (A) Epoch of low-sun spectra 29 seconds before green-flash; (B) Epoch of green-flash spectra.

to be useful for analysis. In both series the altitude of the sun's upper limb was so low that the solar image was essentially a narrow slit. The length and width of the spectra are 11 mm. and 1/2 mm. respectively. The region covered, λλ3900–6400, is in excellent focus, and four absorption bands, due to tetra-atomic oxygen,[1] can be distinguished.

To the eye, either with or without optical aid, the low-sun spectra consist mainly of two distinct coloured regions, one in the green, the other in the red, the former being apparently about four times as intense as the latter. The smooth background of the beach appears dark purple due to a general diffusion of red and infrared. At a time so near sunset, due to atmospheric dispersion the sun's image is apparently separated out into coloured disks having positions of increasing altitudes with increasing order of refrangibility of the rays, overlapping except at the top edge. Owing to the narrowness of the yellow region, the weakness of the blue, and the almost complete suppression of the orange by the rain bands, everything proceeds almost as if only two monochromatic disks,

the red and the green, were partly overlapping and setting one after the other, the green being about 20 seconds of arc higher than the red.[2] The green flash appears to the naked eye from the moment the red disk has set and lasts until the green fringe also is gone. Its duration and intensity are greatly modified by mirage conditions, if such be present. It is possible to see the green fringe with a telescope several minutes previous to setting. At an altitude of 4 minutes the red segment has not yet set.

The green-flash spectra appear as a band of green with an intensification in the λ5300 region. The magenta-coloured background is much less dense than in the low-sun spectra. Although the exposures were exactly the same length in both series, and the sunlight had decreased in general intensity, the total integrated intensity of the green-flash spectrum appeared to exceed that of the low-sun spectrum by a factor of about three. The two series show a great difference in general photographic density, and for this reason it is not possible to decide from visual inspection which spectrum really contains the most intense maximum. Because of the difference in general density levels and backgrounds, inspection leaves one doubtful whether the apparently more dense green region on a very dense background, as in the low-sun spectra, or the less dense, more uniform, and wider green region on a less dense background, as in the green-flash spectra, has the more intense maximum of illumination. It was therefore decided to obtain green extractions of both series of spectra and to subject these to a more objective study of the intensity distribution.

The Green Extractions

A microphotometer can register only to a very slight degree a variation of intensity along a spectrum recorded on colour film, because all three primary dyes are present in the same total amounts at all points of the film, their proportions varying with changes in colour. If an extraction of one colour is made, the density of that colour on the original film is replaced by black silver grains, permitting an objective study of the distribution of intensity of that colour along the spectrum. Through the excellent craftsmanship of Mr. W. E. Murphy of Seattle, satisfactory green extractions of the low-sun and green-flash spectra were obtained. In order to obtain the green extractions a contact print was made of the original colour films on Panatomic-X film. For this purpose the strips of colour film containing the two series were placed side by side in contact with the blue sensitive film and exposed five seconds to light from a daylight lamp shining through a Wratten C5 filter, having its maximum of transmission at about λ4400. The films were developed together in the same bath for the same length of time. The exposure was so chosen

that for both strips the darkest and lightest portions to be measured fell within the most effective range of intensity of a standardized photographic intensity scale of twelve equal steps, with a step ratio of 0.7. Since, however, standardizing exposures were not impressed on the original colour films, no accurate values of the intensities can be obtained from the present material, but approximate relative intensities may be

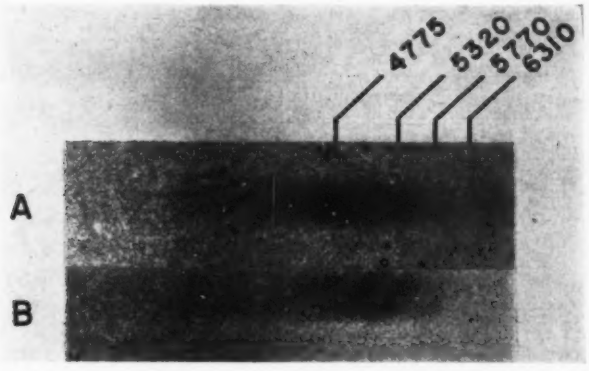

FIG. 2—Diffraction camera spectra, enlarged 6.6 times. (A) Low-sun spectrum, 29 seconds before green-flash. (B) Green-flash spectrum.

significant. A visual inspection at this stage of the positive (i.e., black and white) green extractions shows an apparently brighter maximum in the green region for the low-sun series than for the green-flash series. However, the background of the beach is also much brighter in the former series, and a visual inspection leaves one in doubt as to which green maximum rises the higher above its corresponding background.

THE MICROPHOTOMETER TRACINGS

During the summer of 1950 microphotometer tracings were made at the Dominion Astrophysical Observatory, on the same strip of photographic paper, of the best six consecutive low-sun spectra, the best five consecutive green-flash spectra, the backgrounds close to each spectrum, and the standardized intensity wedge. These tracings are on a logarithmic scale and direct intensity tracings were obtained by means of an intensitometer utilizing an inverted logarithmic curve. As a check on the work at this stage, the graph of equal-intensity steps on the standardized scale was a series of equidistant horizontal lines. These afforded a means of ruling equal-intensity ordinates on all the tracings. Abscissae were laid off in centimetres from a zero point on the redward edge of each frame, with a value of twenty-two in the violet portion of the spectrum. Although

the step value of the intensity scale is known, this has no simple connection with the density in the original spectra. However it should be possible to determine approximate relative values of the intensities at the same wave-lengths in the two series of spectra by adopting the following reasonable assumptions: (*a*) that the properties of the film are the same in the two series; and (*b*) that there exists at each wave-length a monotonically increasing relation between the intensities in the sources and the blackening in the green extractions. Then it is possible, after the background has been eliminated, to compare the relative intensities at the same wave-length in the two series of spectra, although the quantitative relations will at best be approximate.

The Wave-Length Scale

A simple computation shows that due to the width of the solar image two spectral features in the green region, to be just resolved, must differ in wave-length by about ten and two angstrom units for low-sun and flash spectra respectively, but the corrections to the ordinates of the spectral intensity curve, due to this impurity, never in excess of one per cent., are considered to be negligible. Both series show four absorption bands, whose positions are easily read off in centimetres on the intensitometer tracings. After some experimenting it appeared that the observed absorptions were the Jansen bands at λλ6310, 5770, 5320, and 4775, recently studied by Keilin and Hartree.[1] Their wave-lengths were plotted against their measured positions and a smooth curve drawn through the points was adopted as the dispersion curve for the spectrum.

The Spectral-Intensity Curves

In the process of making the green extractions the light transmitted by the C5 Wratten filter produced blackening at all wave-lengths along the spectrum. If the assumption is made that at each wave-length there is proportionality between the source intensity and the ordinate of the

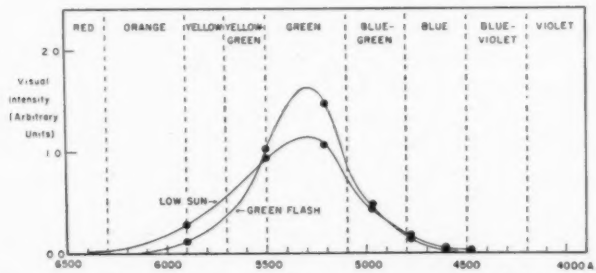

Fig. 3—Spectral intensity curves of low-sun and green-flash (photographic).

intensity trace, one can construct the spectral intensity curve for each spectrum. For this purpose ordinates were read off at twelve equidistant positions in the intensity tracings of both green flash and low sun, and

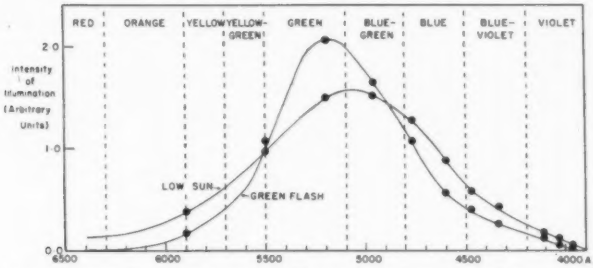

FIG. 4—Spectral intensity curves of low-sun and green-flash (visual).

TABLE I

DATA FOR SPECTRAL INTENSITY AND SPECTRAL VISIBILITY CURVES OF GREEN-FLASH AND LOW-SUN SPECTRA

Wave-length in A	Observed Intensity of Illumination		Ratio of Observed Intensity Green Flash/Low Sun in percentage	Relative Sensitivity of Human Eye	Visual Intensity	
	Green Flash	Low Sun			Green Flash	Low Sun
6370 meas.	(0)	0.13	–	0.20	(0)	0.026
6200	0.020	0.16	12.5	0.38	0.008	0.061
6000	0.075	0.29	38.7	0.64	0.048	0.19
5900 meas.	0.16	0.37	43.2	0.77	0.12	0.28
5600	0.60	0.75	80.0	0.99	0.59	0.74
5525	0.90	0.90	100.0	1.00	0.90	0.90
5500 meas.	1.06	0.97	109.0	0.98	1.04	0.95
5410	1.48	1.13	131.0	0.95	1.41	1.07
5300	1.90	1.34	141.7	0.86	1.63	1.15
5280	1.95	1.35	144.5	0.83	1.64	1.16
5200 meas.	2.06	1.50	137.3	0.72	1.48	1.08
5180	2.07	1.52	136.1	0.71	1.47	1.08
5090	1.96	1.60	122.5	0.46	0.90	0.74
5000	1.76	1.55	113.5	0.31	0.55	0.48
4970 meas.	1.66	1.52	109.2	0.29	0.48	0.44
4900	1.46	1.46	100.0	0.23	0.34	0.34
4800	1.17	1.34	87.3	0.15	0.18	0.20
4770 meas.	1.07	1.28	83.5	0.14	0.15	0.18
4700	0.82	1.13	72.5	0.09	0.074	0.102
4600 meas.	0.56	0.88	63.7	0.06	0.034	0.053
4470 meas.	0.40	0.58	69.0	0.05	0.020	0.028
4330 meas.	0.26	0.43	60.4	0.02	0.005	0.009
4300	0.24	0.37	64.8	0.01	0.002	0.004
4220 meas.	(0.19)	0.28	67.8	0.005	0.001	0.001
4120 meas.	0.12	0.18	66.7	0.001	0.000	0.000
4030 meas.	0.05	0.12	41.7			
4000	0.02	0.08	25.0			
3970 meas.	0.005	0.03	16.7			
3900	0.000	0.000	–			

by subtracting the corresponding background value, the ordinates of the spectral intensity curves were obtained. The abscissae were converted into angstrom units by means of the dispersion curve. The resulting spectral intensity curves for green flash and low sun are shown in figure 3. The data used in constructing the curves are shown in columns 1, 2, and 3 of Table I, where the entries marked "meas." indicate measured values. The remaining entries were read from the curve, as were the two entries in parenthesis where the measured values were replaced by smoothed values.

Table I also contains the data for the determination of the spectral visibility curves, obtained by multiplying each ordinate of the spectral intensity curves by the corresponding ordinate of the spectral sensitivity curve for the normal human eye.[3] For this purpose use was made of the photopic curve having a maximum of sensitivity for equal energy sources at λ5500, which applies to sources sufficiently bright to render the Purkinje effect negligible.

Inspection of the photographic spectral intensity curves in figure 3 indicates maxima of 2.07 and 1.60 on an arbitrary scale, at λλ5180 and 5090 for the green flash and low sun respectively. The ratio of these maxima is 1.3. The visual spectral intensity curves in figure 4 show maxima of 1.64 and 1.16 respectively, on the same arbitrary scale, both at λ5280.

If we define the quantity of light in a certain spectral region as the integral $I_\lambda d\lambda$ within the limits of the region, the areas under the curves are proportional to the quantity of light, and the measurement of the areas gives information about the ratio of the average light intensities in two different regions of the same spectrum, or in the same (or different) regions in two different spectra. Performing these measurements by means of a planimeter, and adopting the usual wave-length limits for the different colours of the spectrum,[3] a determination was made of the average relative intensities of the colours in the green-flash and low-sun spectra. The data are entered in Table II, where the headings of the columns are self-explanatory.

For the whole spectrum the ratio of the areas under the curves is 0.99, so close to unity that the values in Table II are considered to be directly comparable for samples of equal total intensity of green flash and low sun light.

The conclusion to be drawn from Table II is that the composition of the sunlight reaching the observer during a green flash is definitely so changed as to throw more intensity into the green and blue-green regions of the spectrum. The common statement that the colour of the flash usually corresponds effectively to that of light of λ5300 is in good agreement with figure 3, the visual intensity curve. It seems probable from figure 1 that

TABLE II

RELATIVE INTENSITIES OF COLOURS IN GREEN-FLASH AND LOW-SUN SPECTRA

Colour	Wave-length Interval in A	Ratio of Areas under Curves Green Flash/Low Sun
Orange	5900—6300	0.354
Yellow	5700—5900	0.548
Yellow-Green	5500—5700	0.836
Green	5100—5500	1.36
Blue-Green	4800—5100	1.08
Blue	4500—4800	0.718
Blue-Violet	4200—4500	0.613
Violet	3900—4200	0.577

the total intensity of sunlight decreases considerably between the moments of exposure of the low-sun and green-flash spectra. The ratio of the ordinates of points on the curve of figure 1 at these moments is close to three, so that, since the total areas under the curves of figure 2 are nearly equal, there was a true increase in light, mainly of the green, at the time of the flash to bring about this equality. The flash was thus a real brightening of green light just preceding sunset.

GENERAL DISCUSSION

According to Mulders,[4] the green flash is "the final development and sudden disappearance of the bluish green fringe on the upper part of the sun's limb." With this partial definition, it is obvious that an intensification of the green part of the spectrum is not to be expected, inasmuch as the progressive setting and absorption of the green edge more than compensates for its widening by atmospheric dispersion. In numerous instances an actual intensification of the green light as compared to the total residual sunlight just preceding the flash, by a factor of above ten, has been reported or implied in the description of the observations. Whenever an intensification is observed, it seems reasonable to assume that a mirage condition or a reflection from an inversion layer must enter into the explanation of the phenomenon. As the clearness of the atmosphere increases, the colour of the flash becomes bluer. During the Okinawa campaign in 1945, under the unusually clear atmospheric conditions in the cold fronts sweeping the North Pacific Ocean, the sunset flash was seen many times by members of the United States Navy. It was described as of an "electric blue" colour and reported to be "as bright as a ship's searchlight in day time at a distance of 10 to 15 miles." According to one veteran observer,[5] the intensity of the flash under the best conditions "is very much brighter than the residual light on the horizon just preceding.

It is about equal to the full reflection of the sun's image from a car windshield at a distance of three or four miles from the observer." Although the flash discussed in the present study was not of this intensely brilliant kind, it was definitely a brightening of the last trace of sunlight due to a mirage condition, and not just "a development and disappearance of the green fringe." While the latter phenomenon can be duplicated almost at will in mountainous regions with the appearance of an electric blue, intense blue (Lord Kelvin, at Mont Blanc),[6] or even violet colour,[7] a true green flash in the original sense of the term, involving a considerable intensification of the green, is very rare, except in certain favourable localities, and probably always involves a mirage condition for its manifestation to occur. The present study, however qualitative, is probably the first based on proper observational material. A visual observation of the green-flash spectrum has been reported earlier,[8] but a study of its photographic record has not to the author's knowledge been made previously. The photographic observations of Danjon and Rougier[2] were low altitude records of the green fringe, disk centre, and red fringe spectra; they were definitely not green-flash studies because the exposures on the spectrograms were stated by the authors to be each of the order of two minutes' duration.

In conclusion the author wishes to express his thanks to Mrs. Patsy V. Sinkey, photographer, who generously turned over to him her green-flash films for scientific analysis, and to Dr. J. A. Pearce, who put at his disposal the resources of the Dominion Astrophysical Observatory necessary for the present study.

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Dominion Astrophysical Observatory,
Victoria, B.C.,
November 13, 1951.

COMMUNICATIONS
FROM THE
DAVID DUNLAP OBSERVATORY
UNIVERSITY OF TORONTO
Number 29

A NEW DETERMINATION OF THE ORBIT OF H.D. 224085

By Ian Halliday

The orbit of the spectroscopic binary H.D. 224085* was published by R. F. Sanford in 1921.[1] In connection with one of the David Dunlap Observatory programmes six spectrograms of this star had been obtained between 1946 and 1950. The six observations of radial velocity secured here are as follows:

J.D. 2,432,100.726	−46.7	±0.5 km./sec.
2,873.563	−34.2	±1.2
3,149.832	−36.4	±1.1
3,199.728	−05.4	±0.6
3,507.878	−36.8	±0.9
3,542.774	+03.3	±2.5

(The first, fourth, and fifth observations were taken with a dispersion of 33A./mm.; the others with 66A./mm.).

It seemed that the long time interval between Sanford's observations and ours afforded an opportunity to improve the period of the binary system. It was found that, with Sanford's period of 6.7217 days, a phase-error of three or four days had accumulated in the thirty years. It was not clear, therefore, whether the new period should be longer or shorter than Sanford's value. Both adjustments were tried and the scatter was found to be much less with the longer period, the best graphical estimate being 6.7243 days. A test for spurious period was made, using the method described by R. W. Tanner.[2] The two related periods are approximately 0.868 days and 1.171 days and both were ruled out by the test.

The change in the period is sufficient to affect the shape of the velocity curve somewhat, so it was decided to recompute the whole orbit by least squares. The observations used were the six Dunlap values and twenty-one of Sanford's twenty-five measures. Four plates which Sanford de-

*Lalande 46867: R.A. $23^h\ 49^m.9$, Dec. $+28°06'$ (1900).

scribed as underexposed or out of focus were rejected. In the solution the period was retained as a variable in order not to bias the other parameters. The least-squares solution was performed by the use of Cracovian matrices.[3] In this method the addition of an extra variable does not lead to a great increase in the amount of calculation. Sterne's method[4] for small eccentricities was employed, and the quantity T_o is his "epoch of the mean longitude." Tabulated below are Sanford's elements, the revised preliminary values, and the final elements with their estimated probable errors.

	Sanford	*Preliminary*	*Final*	
P	6.7217 days	6.7243	6.724183	± 0.000034
e	0.059	0.000	0.032	± 0.026
ω	18°.6		324°.8	±45°.3
K	38.5 km./sec.	38.5	37.3	± 0.98
γ	−19.8 km./sec.	−18.5	−18.1	± 0.65
T_o		220.2403	220.3553	± 0.0318
T	220.7403		219.6986	
a sin i	3.5523×10^6 km.		3.4484×10^6	
mass fn.	0.0125 ⊙		0.0361 ⊙	

T_o and T = J.D. 2,422,000 +

The least-squares solution reduced the squares of the preliminary residuals by 30 per cent. Due to the small eccentricity of the orbit the value of ω can not be determined with accuracy. Apparently there was a numerical error in Sanford's value of the mass function.

The H and K emission components are present on all six Dunlap plates and the velocities from them seem to agree with those found from the other absorption lines. In addition to the emission feature, the spectrum is unusual in the extreme weakness of the hydrogen lines. The writer has classified the spectrum as K0 V on the Morgan system[5] which leads[6] to an absolute magnitude of +6.0. This is in exact agreement with the spectroscopic value quoted by Sanford.

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David Dunlap Observatory,
Richmond Hill, Ontario,
April, 1952.

THE ORIGIN OF THE PLANETS*

By A. Vibert Douglas

Man has been endowed with mind and with an insatiable curiosity which leads him to look out upon his surroundings, ask questions and seek to find answers. He is first conscious of himself and his immediate environment, then he begins to consider other people and the earth on which he dwells—land and sea and atmosphere, rocks, soil, insects, birds, fish, animals, and the luminous bodies in the sky, sun, moon, planets, stars.

From what he perceives he very soon learns to infer the existence of things which he does not see. He learns to generalize, and where there are no simple answers to his questions, he begins to speculate. He forms theories and tests their validity in the light of further knowledge.

To the seeker after truth a theory is a tool not a creed; and willingness to alter or discard a theory, if it prove unsatisfactory as new knowledge is gained, is of the very essence of honest truth seeking.

One of the questions that has been asked in every age is the origin of the earth. It is part of a wider question, namely, the origin of the solar system, and this in its turn is part of the still vaster question, the origin and development of the entire physical universe.

Many early peoples formulated creation myths and allegories. The poetic account current amongst the early Hebrew people, as set forth in Genesis I, is by far the most dignified and lofty of any of which there is record. "In the beginning God created the heaven and the earth."

No one knew, 2500 years ago, that the earth was not the centre of the universe. Today we know that our planet is one of nine planets moving in elliptic orbits about the sun, and that four planets are smaller and four very much larger than the earth, while the sun is more than 700 times as massive as all the planets together, and is so hot that it is completely gaseous and radiates heat and light continuously at five hundred thousand million million million horsepower. Nor did anyone know until recent years that our sun is one star amongst 100,000 million stars in this great galaxy, and that there are many million other galaxies. Truly man's conception of God must be no small timid limited conception, if He be the Creator of all the vast universe in which the most profoundly beautiful mathematical laws are found to control electrons, atoms, stars, and radiant energy. The Psalmist wrote: The heavens declare the glory of God. The more science has discovered of the vastness of the universe and of the operation of the laws of nature, the greater is that glory.

The German philosopher Emmanuel Kant in 1755 and the French

*Adapted from a radio address over CKWS, Kingston, February 10, 1952.

mathematician Laplace in 1796 gave speculative accounts of the origin of the solar system which influenced thought throughout the nineteenth century. The sun was assumed to be surrounded by a disk-like gaseous nebula out of which, by processes not well understood nor well formulated, the planets were supposed slowly to condense, and satellites to condense about the planets or at least about some of them. But increased knowledge of the dynamics of the solar system made these theories untenable about fifty years ago.

In 1910 two American scientists, Chamberlin and Moulton, formulated the Planetesimal Theory. Another star was presumed to have approached close to our sun some 3000 million years ago, (and there are sound logical reasons for these large numbers) and this resulted in loss of some of the sun's gases which would circle round the sun, condense into small solid aggregates and these into planets and satellites and swarms of meteors.

Two British scientists, Jeans and Jeffreys, developed the tidal theory, putting it on a mathematical basis consistent with assumptions which seemed reasonable at the time. The passing star would draw out a great tidal wave of solar gases and from this matter the system of planets and satellites would slowly be formed. Subsequent critical study of this theory, chiefly by Professor Harold Jeffreys himself, has led to its abandonment. It cannot explain all the known features of the solar system. The list of criteria about the solar system which a theory must explain to be acceptable grows greater and greater as our knowledge increases.

Russell in the United States and Lyttleton in Great Britain suggested that our sun was once one member of a binary star system and that a passing star collided with the sun's companion star knocking it out of the sun's gravitational field but hurtling some of its disrupted gases towards the sun, and from these gases the planets were formed in the course of time.

An Indian, Banerji, proposed a variation upon this, supposing the sun's companion star to have been a pulsating variable star thus facilitating its disruption.

A young Yorkshire scientist, Hoyle, proposed another idea in 1945. His name is now well known because of his BBC and CBC broadcasts describing his hypothesis that the sun's companion became a supernova, an exploding star with the liberation of energy taking place off-centre, thus hurling itself, by recoil or "back kick," out of the sun's influence but hurling its disrupted gases towards the sun to be captured and in due time to condense into planets. Hoyle has a most amazing confidence in his own theory in spite of many very serious inherent difficulties. Relatively few astronomers agree that this is a hopeful approach towards a solution of the origin of the planets; but may the day never come when

the CBC will deny its facilities to a serious thinker so long as he expounds his views without holding up to ridicule the scientific, philosophical, or religious views of those with whom he differs.

Let us now consider what many astronomers believe to be the most encouraging line of attack on this vastly complicated problem.

We leave the cataclysmic theories and consider a star whose motion in the galaxy carries it into one of the many vast regions of diffuse nebulosity consisting of atoms, molecules, and small particles like smoke or fine dust. In 1944, in Germany, C. F. von Weizsäcker investigated the turbulent motion, the vortices and counter eddy currents that would be set up in the shell of a nebula which would form around the rotating star. He showed by calculation that successive rings of successively larger vortices would arise and between these, in what might be called ball-bearing eddies, matter would tend to collect. The resulting sequence of distances and diminishing densities of the aggregates resembles the actual sequence of the planets. This is a theory of great promise and many scientists, e.g. the Astronomer Royal Sir Harold Spencer Jones and Professor Gamov, consider it the most successful theory yet proposed.

Kuiper in the U.S.A. has criticized von Weizsäcker's theory in some respects and has proposed a modification. He concludes that not within the roller bearings will condensation occur, but within the larger primary vortices which will become unstable and give rise to internal eddies from which planets and their satellites might be formed. Kuiper has recently elaborated his ideas in fifty pages of closely reasoned arguments, assumptions, and approximate calculations.

This new Nebular Hypothesis is very different from those of Kant and Laplace. It is based on vastly greater knowledge of physics, astronomy, and mathematical methods. I have not attempted to explain technical ideas—angular momentum, retrograde motions, Roche's limit, ionization, vapour pressure, and many other factors which must be taken into account. Nevertheless I have tried to give some idea of the magnitude of this complicated problem, rendered the more difficult because we do not know and cannot yet observe whether there be few or many other stars which have a family of planets like our sun's system.

Only since 1942 have we known that any other star possesses even one planet. In that year and the next, K.A. Strand drew attention to the binary star 61 Cygni, and Renyl and Holmberg to the binary 70 Ophiuchi. In each of these systems a third component of mass so low as to place it in the category of a planet has been inferred, though not observed.

The two visible stellar components, A and B, of 61 Cygni revolve in orbits about their common centre of gravity in a period of 720 years. Much is known about orbital motion as a result of the work of Kepler

and Newton. Observed deviations from a Keplerian orbit imply the existence of a third body whose mass and orbit can be calculated. From the motions of A and B, Strand has established not only the existence of C, but the fact that it revolves about either A or B in 4.9 years and that its mass is only sixteen times that of the planet Jupiter or one-sixtieth of the sun. Too small to be called a star, 61 Cygni C is the first body classified as a planet to be found outside the solar system.

In the richest starry regions of the Milky Way is another binary system, 70 Ophiuchi. Its visible component stars A and B revolve in an 88-year period. They, too, show deviations from true binary star orbits, necessitating the conclusion that a third body C exists. Between 1914 and 1942 at an American observatory 97 plates were taken of this pair, and another 29 plates were borrowed from Germany and from South Africa, from all of which the conclusion is reached that C revolves in an orbit around either A or B every 17 years. Its mass is about one-hundredth of the mass of the star to which it is a planet.

Might there be life on these planets, vegetation and animal life such as have come into being on the earth in the course of many millions of years? Terrestrial organisms of self-reproducing cells are known to require special chemical and environmental conditions—abundance of carbon and hydrogen, water vapour, and a limited range of temperature being only the most obvious. While the central mystery of life remains a mystery, no logical reason forbids the assumption that living cells will come into being wherever in nature the requisite chemical and physical conditions exist. In the case of the other members of the solar system no close approximation to the essential terrestrial conditions is found: too scorchingly hot if near the sun; too utterly cold if in the outer orbits; no atmosphere whatever, or atmospheres almost devoid of oxygen and water vapour but rich in carbon dioxide, or methane, or ammonia as cirrus clouds of crystals hovering over a frozen ocean of solid ice.

Examining the data for the two non-solar planets we find that 61 Cygni C revolves about its star in an elongated elliptic orbit which brings it in to about the sun-Venus distance but carries it far out beyond the sun-Mars distance. The average distance of this planet is therefore much greater than the sun-earth distance. Both for this reason and because its star is much cooler and less luminous than the sun, the temperature may be too low to be conducive to life even if the other conditions were favourable.

Cooler also than the sun, though to a lesser extent, are 70 Ophiuchi A and B, but 70 Ophiuchi C revolves around one of them at approximately six times the sun-earth distance. It is thus more remote from its star than Jupiter from the sun. Jupiter is believed to be wholly incased in ice, so that the likelihood of life on 70 Ophiuchi C is negligible, in so

far as temperature plays a decisive part. What the chemical and the other physical properties of these unseen non-solar planets may be we do not know.

When one pauses to consider that the galaxy of which our sun is one humble member is composed of some hundred thousand million stars, and that there are possibly a hundred million such galaxies within reach of our powerful telescopes, the conclusion is justified that many planetary systems must exist whether the number in any one galaxy be large or small. Amongst all these some few here and there in this galaxy or in another may happen to provide those very conditions of environment in which living cells may develop. This is a vague statement but it is based on long years of observation and research in which much precise knowledge has been gained. The past ten years have added their quota. What new knowledge will the next few years reveal? Perhaps astronomers will find indirect evidence of planets about many other stars, and perhaps in the years not too far distant a direct observation will be made of some non-solar planet. But in any case the search for answers to the problems of astronomy and cosmology will go on because man is so made that he cannot resist the challenge of the unknown.

REVIEW OF PUBLICATIONS

Les Atmosphères Stellaires, by Daniel Barbier. Pages 238, 5 x 7½ in. Paper bound. E. Flammarion, editor, 26 Rue Racine, Paris, 1952. Price 625 francs.

This book, written in French, serves a useful purpose in presenting a concise account of our present knowledge of stellar atmospheres. It does not presuppose an extensive knowledge of astrophysics, but does require a reasonably good foundation in both physics and mathematics.

The author is an astronomer at the Paris Observatory, and the book has both a preface and an appendix by Professor F. Croze of the Paris Faculty of Sciences. The former is a brief history of spectroscopy, the latter a note on the identification of "nebulium." The book itself deals with many problems of stellar atmospheres and their spectra, including spectral classification, equilibrium considerations, absorption coefficients, line contours and intensities, Stark effect, and emission lines. There is a brief discussion of molecular spectra in astronomy, and an interesting appendix by the author on the solar chromosphere and corona. Due to the wide field covered, some of the topics necessarily receive only a brief discussion.

Throughout the book a balance is maintained between theory and the results of the latest observational tests. Equations and formulae of a fundamental nature are given, usually without formal derivations. Numerous graphs and tables accompany the text. The contents of this volume seem to deserve a better binding than the present paper one.

IAN HALLIDAY

Notre Univers Merveilleux, by Clarence Augustus Chant, translated by Paul-H. Nadeau. Pp. 281, 5½ x 8⅜ ins. Published by La Société Royale d'Astronomie du Canada, Centre de Québec, 1952. Price $3.00.

The many readers of Dr. Chant's handy and pleasing volume *Our Wonderful Universe* will be pleased to learn that it has now been translated into French by Mr. Paul-H. Nadeau, Director of the Quebec Observatory, and published by the Quebec Centre of the Royal Astronomical Society of Canada with the financial support of the Government of the Province of Quebec. This brings to six the number of languages in which this delightful book has now been published, as editions in

German, Polish, Czechoslovakian, and Spanish have already appeared. From its first appearance in 1928, through the 1940 edition which was greatly revised and amplified, *Our Wonderful Universe* has had a well-merited popularity.

The French edition loses nothing of the pleasing make-up of the book, as the original photographs are admirably reproduced on fine paper, and the sky maps and diagrams have been remade when necessary, with French names. This edition is practically a true copy of the English book, page by page; and the two volumes should make a handy pair for anyone who wishes to become acquainted with astronomical terms and ideas in the two languages. There are some small changes such as footnotes which bring the book up to date on the new satellites of Uranus and Neptune, and the final photograph of the Martello Tower of the Quebec Observatory on the beautiful Plains of Abraham in Quebec City.

We wish for *Notre Univers Merveilleux* as successful a career as its original has already had. All the proceeds from the sale of the French edition are to be donated to a fund for a future observatory in Quebec.

H.S.H.

Palomar, The World's Largest Telescope, by Helen Wright. Pages 188, 5½ by 8¼ inches. Macmillan Co., New York, 1952. Price $4.50.

Now that the 200-inch Hale telescope is gloriously and successfully in action it is logical that we have a sequel to David O. Woodbury's popular volume *The Glass Giant of Palomar*, published in 1939 when the final success of the instrument was still in doubt. And Helen Wright, with a flare for carefully sifting and recording documentary stories is an excellent choice to tell the tale. A preface by Dr. I. S. Bowen, Director of the Mount Wilson and Palomar Observatories, indicates that she is also the official choice.

Palomar is written somewhat more for the person with astronomical background than was its predecessor. It contains a wealth of detail and names. This makes it a very satisfactory step-by-step account of the progress of the telescope to its final triumphant completion. Particularly do we follow the hopes and fears of George Ellery Hale himself, without whose vision the telescope would probably not yet have materialized. *Palomar* does not just pick up the story where *The Glass Giant* left off—it begins at the beginning and covers the whole picture, through the dedication of the huge instrument as the Hale telescope, years after Hale's death. It includes a beautiful picture of the newly found Cone Nebula, proving that man's faith in the great penetrating powers of the 200-inch is amply justified.

It would appear to this reviewer that both of these excellent books about the 200-inch telescope have titles which do not do them justice. *The Glass Giant of Palomar* has been mentioned as the kind of title to confuse librarians, who may think it a fairy story. (At that, it seems like a fairy story!) The title of the present work is more explicit, but "Palomar" and "The World's Largest Telescope" are not completely synonymous. Three ideas seem intermingled here—the mountain, the observatory, and the giant telescope. A great deal of the climax of the book comes in the naming of "the world's largest telescope" as the "Hale telescope," and the title of the book seems in confusion to this idea.

H.S.H.

Astronomie: Geschichte ihrer Probleme, by Ernst Zinner, with 34 illustrations. Pages 404, 5½ x 9 inches. Freiburg and Munich: Verlag Karl Alber, 1951. Price DM 23.

It has been remarked that astronomy has exerted a powerful influence on human thought. Intelligent men in early ages endeavoured to account for various phenomena observed in the heavens and their views have been continually criticized in the succeeding centuries. This book aims to give a clear outline of the whole story of the development of the subject.

Professor Zinner is Director of the Remeis Observatory in Bamberg and is a competent scholar. In his systematic treatment of the subject various topics are discussed and are associated with distinguished discoverers and writers. For example, the first ten topics are: *Plato*, Heaven and Earth, 5 pp.; *Aristotle*, World-building, 16 pp.; *Ptolemy*, Motions of the Planets, 34 pp.; *von Cues*, Planetary Motion, 2 pp.; *Copernicus*, Preface, 13 pp.; Motion of the Planets, 31 pp.; *Kepler*, World-secrets, 10 pp., New Astronomy, 7 pp., World Harmony, 11 pp.; *Newton*, Theory of the Planets, 67 pp. In all there are 74 such topics.

Sometimes direct quotations are given, with appropriate introductory remarks, but more often the substance is given in more modern words. At the end is given (1) a list of the sources from which quotations are made, 5 pp.; (2) a bibliography, 7 pp.; (3) an index, 9 pp.

The book is well produced.

C.A.C.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

The Introduction of the Copernican System to England

I. Robert Recorde and the *Castle of Knowledge*

A great amount has been written about the impact of the Copernican ideas on Italy, and the violent upheavals, even persecutions, which resulted there. This is natural because Galileo alone stands out as a dramatic figure representing a new observational era in astronomy, with its conflict with existing ideas. It is however unfortunate that in our astronomical literature the reception of the Copernican ideas in one country should almost completely overshadow the reactions which they received elsewhere. It is natural that histories of astronomy concern themselves almost entirely with the men who have actually added new knowledge to the subject. However, the astronomical torch can be carried by teachers as well as by research scientists, and it is a pity that, when centuries elapse, these astronomical torch-bearers tend to be forgotten. For example, Berry in his excellent *A Short History of Astronomy* dismisses the English work of this period with a single paragraph.

We have already mentioned in this section (this Journal, May-June, 1949) that the name of Jean Sylvain Bailly is more familiar to students of history than to students of astronomy. Similarly in the case of several sixteenth-century English astronomers, the students of English history and literature know them far better than the twentieth-century astronomers do. For this reason we propose to print a series of articles on these men who deserve much wider recognition by astronomers to-day.

For this material we are largely indebted to a masterly volume by Francis Rarick Johnson, *Astronomical Thought in Renaissance England*, published by the Johns Hopkins Press, Baltimore, 1937, pp. 357. This volume is one which every student of the history of astronomy should read. It represents a vast amount of research on the part of the author. Many extracts from the early works of the sixteenth century are given, and some of these, along with Johnson's comments, we shall reprint, by kind permission of the Johns Hopkins Press, in order that our readers may see for themselves the intelligent thinking of English scientists.

According to Johnson, the earliest known discussion of the Copernican system in English was published by Robert Recorde in 1556 in his volume, the *Castle of Knowledge*. Robert Recorde is best known and usually referred to as a mathematician—it was he who invented the sign

of equality, =, which we use to-day. However, a brief survey of his life as given in the *Dictionary of National Biography* indicates that he dipped into practically all fields of learning, and was well qualified in many of them. Since the publication of this biography more recent research (for example, by Frances Marguerite Clarke in *Isis*, vol. 8, 1926) has unearthed new facts, and rendered obsolete some of the information in it. A hitherto unknown portrait of Recorde has also come to light in recent times. Purchased at a sale at Harrow by Rev. Done Bushell, it was first published by David Eugene Smith in the *American Mathematical Monthly*, vol. 28, 1921, from which it is reproduced here. The original is now in the National Portrait Gallery in London.

ROBERT RECORDE, 1510(?)–1558

Born about 1510, of a good family in Tenby in Pembroke, Recorde was admitted to Oxford in 1525, and received a B.A. there, and perhaps an M.A. as well. In 1531 he was made a Fellow of All Souls'. Then he proceeded to Cambridge where he achieved a high reputation as a teacher. He read and taught mathematics and medicine, "which he rendered clear to all capacities to an extent wholly unprecedented." At Cambridge he received the degree of M.D. in 1545. After this he returned to Oxford where he taught arithmetic and mathematics, rhetoric, anatomy, music, astrology, and cosmography. There is no record that he ever married. In 1547 he was a practising physician in London, and became physician to King Edward VI and Queen Mary.

In 1549 he was appointed Comptroller of the mint at Bristol, and in 1551 Surveyor of the Mines and Monies of Ireland. This latter seems to

have been a difficult post. At any rate, after some years of it Recorde was imprisoned, and died in King's bench prison at Southwark in 1558. The exact reason for his imprisonment remains unknown. It may have been connected with his management of the mines in Ireland; or it may have been of a political or religious nature. It appears probable that whatever the offence, it was not the sort which leads to imprisonment now in a democratic country.

He was conversant with every branch of natural history and with the coinage; he knew Anglo-Saxon, was "no mean divine," and was acquainted with law. As a zealous antiquary he made a large collection of historical and other ancient manuscripts. He was the founder of the English school of mathematical writers, the first to introduce algebra into England, and the first to write in English on arithmetic and astronomy. In addition to the *Castle of Knowledge*, he published other excellent books including the *Grounde of Artes*, the *Pathway to knowledg*, and the *Whetstone of Witte*.

Johnson describes the *Castle of Knowledge* as follows (page 125):

The Castle of Knowledge is a handsomely printed small folio of three hundred pages, containing many well-designed illustrations and geometrical diagrams. The book was dedicated to Queen Mary, and had a prefatory epistle addressed to Cardinal Pole. The plan and arrangement of the work demonstrate Recorde's skill and insight as a teacher. He particularly emphasizes the importance of the proper method and order in instruction, insisting, in the first place, that the student must be well grounded in arithmetic and geometry before attempting to learn astronomy. For this reason, Recorde expects his two earlier books, the *Grounde of Artes* and the *Pathway to knowledg* to have been thoroughly mastered before beginning the *Castle*. Assuming this preparation, Recorde proceeds, in accord with his ideas of the proper order in teaching, to present the fundamental principles and concepts underlying the science of astronomy, having the student construct his own celestial sphere to assist him in grasping these basic ideas.

Like the two previous books, the *Castle* took the form of dialogues between master and pupil, a popular method of presenting knowledge in those days. We quote a passage, *Castle*, pp. 164–5, which shows that Recorde considered that Aristotelian and Ptolemaic arguments against the earth's rotation were false, and in which he suggests that he will propound the revolution of the earth when the stùdent has become intelligent enough to understand it. Though this passage is in early English spelling, it should not give the reader much difficulty; the most noticeable change is that our present letter v is a u in this period.

Master. But as for the quietnes of the earth, I neede not to spende anye tyme in prooving of it, syth that opinion is so firmelye fixed in moste mennes headdes, that they accopt it mere madnes to bring the question in doubt. And therfore it is as muche follye to trauaile to proue that which no man denieth, as it were with great study to diswade that thinge, which no man doth couette, nother any manne alloweth: or to blame that which no manne praiseth, nother anye manne lyketh.

Scholar. Yet sometime it chaunceth, that the opinion most generally receaued, is not moste true.

Master. And so doo some men iudge of this matter, for not only Eraclides Ponticus, a great Philosopher, and two great clerkes of Pythagoras schole, Philolaus and Ecphantus, were of the contrary opinion, but also Nicias Syracusius, and Aristarchus Samius, seeme with strong arguments to approue it: but the reasons are to difficulte for this firste Introduction, & therfore I wil omit them till an other time. And so will I do the reasons that Ptolemy, Theon & others doo alleage, to prooue the earthe to bee without motion: and the rather, bycause those reasons doo not proceede so demonstrablye, but they may be answered fully, of him that holdeth the contrarye. I meane, concerning circularre motion: marye direct motion out of the centre of the world, seemeth more easy to be confuted, and that by the same reasons, whiche were before alleaged for prouing the earthe to be in the middle and centre of the worlde.

Scholar. I perceaue it well: for as if the earthe were alwayes oute of the centre of the worlde, those former absurdities woulde at all tymes appeare: so if at anye tyme the earthe shoulde mooue oute of his place, those inconueniences would then appeare.

Master. That is trulye to be gathered: howe bee it, Copernicus, a man of greate learninge, of muche experience, and of wondrefull diligence in obseruation, hathe renewed the opinion of Aristarchus Samius, and affirmeth that the earthe not only moueth circularlye about his owne centre, but also may be, yea and is, continually out of the precise cetre of the world 38 hundreth thousand miles: but bicause the vnderstanding of that controuersy dependeth of profounder knowledg then in this Introduction may be vttered conueniently, I will let it passe tyll some other time.

Scholar. Nay syr in good faith, I desire not to heare such vaine phantasies, so farre againste common reason, and repugnante to the consente of all the learned multitude of Wryters, and therefore lette it passe for euer, and a daye longer.

Master. You are to yonge to be a good iudge in so great a matter: it passeth farre your learninge, and theirs also that are muche better learned then you, to improue his supposition by good argumentes, and therefore you were best to condemne no thinge that you do not well vnderstand: but an other time, as I sayd, I will so declare his supposition, that you shall not only wonder to hear it, but also peraduenture be as earnest then to credite it, as you are now to condemne it.

Recorde's learning was of wide range and his scholarship was thorough. He had studied the Greek ideas of science and philosophy as well as those of Copernicus. Toward them all he preserved an intelligent and unbiased attitude. This is exemplified in a remark concerning Ptolemy (*Castle*, p. 127) which places him well ahead of many men of his, and earlier times, who accepted the voice of authority without question.

No man can worthely praise Ptolemye, his trauell being so great, his diligence so exacte in obseruations, and conference with all nations, and all ages, and his reasonable examination of all opinions, with demonstrable confirmation of his owne assertion, yet muste you and all men take heed, that both in him and in al mennes workes, you be not abused by their autoritye, but euermore attend to their reasons, and examine them well, euer regarding more what is saide, and how it is proued, then who saieth it: for autoritie often times deceaueth many menne.

In conformance with these beliefs, Recorde pointed out errors in the texts of ancient Greek authors, and proceeded to make corrections in

them. For example, Proclus states that the star Canopus which can barely be seen above the horizon at Rhodes was invisible at Alexandria, further south. Recorde (*Castle,* p. 164) says that this is "contrary to common sense," and emends the statement to read "of good appearance," i.e. plainly visible, since Canopus rises several degrees above the horizon at Alexandria.

Recorde accepted the highest knowledge of the Greeks, however, when he adopted the Platonic idea that the secrets of the universe will be unfolded by mathematics. Introductions to his works contain loud praises of the mathematical sciences, showing the reverence in which he held them. An example is from the preface to the *Whetstone of Witte,* where Recorde says:

> It is confessed emongeste all men, that knowe what learnyng meaneth, that besides the Mathematicalle arts, there is noe vnfallible knoweledge, except it bee borrowed of them.

In summary, Johnson ranks the *Castle of Knowledge* as the outstanding astronomical textbook published anywhere in the sixteenth century. This places Recorde as one of the great astronomical torch-bearers. Johnson evaluates the *Castle of Knowledge* as follows:

> Enough has been said of Recorde's textbook on astronomy to show how misleading is the statement in the *Cambridge History of English Literature* that Francis Bacon "was the first to write an important treatise on science or philosophy in English." The *Castle of Knowledge* deserves to rank as the outstanding introduction to the science of astronomy published during the sixteenth century. No other book of its type, either in Latin or in one of the European vernaculars, rivals it in its combination of intelligent pedagogical method, sound scholarship, literary style, and truly scientific attitude toward ancient authorities. Its value was recognized by Recorde's fellow countrymen, and it became the standard work on the subject, holding this place for over half a century. The copyright was jealously guarded, all transfers being entered in the Stationers' Register, and a new edition printed as late as 1596. Recorde's book was imitated, three years after its first publication, by William Cuningham's *Cosmographical Glasse,* and copies of both of these works were included in the ship's library on Frobisher's first voyage, in 1576.

NOTES AND QUERIES

Truman Donald Norton Book Collection

This Memorial Book Collection was proposed by the Hamilton Centre, R.A.S.C., in memory of Truman Donald Norton, who was knocked from his bicycle and killed by a motor car on his way to Boy Scout Camp on May 6, 1951. He was thirteen at the time. He was the only son of Truman M. Norton, who has been active in the Hamilton Centre for many years. Mr. Norton was Vice-President for the years 1946 and 1947, and President 1948 and 1949. He is at present a member of the local Council and has recently been elected to the National Council.

The collection now contains some forty volumes, which cover a wide range of interest in the field of astronomy. It has grown through private donations, and includes some twelve volumes donated by the staff members of the David Dunlap Observatory from their personal libraries.

The collection was formally presented to the Mills Memorial Library of McMaster University on Thursday, October 4, 1951. It now forms an integral part of the astronomical section. By the kind courtesy of Miss Marget Meikleham, Chief Librarian, the members of the Hamilton Centre have full library privileges.

W. J. McCallion

Fire Damage at the Australian Commonwealth Observatory

During an extremely dry summer a lightning stroke started a scrub fire about eight miles to the north-west of the Commonwealth Observatory which is situated on Mount Stromlo near Canberra.

A north-east wind moved this fire towards the Murrumbidgee River and graziers who commenced to fight the fire had hope of controlling it. The fire started on 1952 February 5 at 10h 30m. About three hours later the wind changed to the north-west and brought the fire to the Observatory buildings by about 14h 30m. A high wind swept tongues of flame through ten-year-old pines and a gully of oak scrub (casuarina) towards the Observatory. By ill fortune a woodheap near the Observatory workshop ignited and simultaneously the electric power for the fire hydrants failed. The fire entered the workshop and for an hour or so was out of

control with the available equipment. Aid from the Canberra Fire Brigade was cut off by the main fire raging through the thirty-year-old pine forest to the east of the Observatory. Two cylinders of oxygen and acetylene gas exploded in the workshop and the roof collapsed. This lowering of the fire level enabled a hard-working bucket brigade to prevent the fire from spreading to the adjoining buildings and to save the library and offices. The fire swept on to destroy a considerable area of pine forest before it was halted by the efforts of volunteers in the Bush Fire Council Brigade, aided by a change in the meteorological conditions.

The main Observatory loss was the workshop in which machine tools to a total replacement value of over £25,000 were lost, and a store building containing, among other things, duplicate copies of the now defunct Melbourne Observatory publications. No working telescopes were damaged nor were any of the residences on the mountain destroyed.

Plans for making good the fire loss are under way and the damage, though serious, will not prove an insuperable obstacle to carrying out the development programme of the Observatory. This programme includes the erection of a 50-inch reflector, a 74-inch reflector, as well as buildings for telescopes from the Yale-Columbia Observatory and the University of Upsala.

A. R. Hogg
Commonwealth Observatory

Bruce Gold Medal Awarded to Dr. S. Chandrasekhar

The Astronomical Society of the Pacific announced at its annual meeting on January 29, 1952, that the Bruce gold medal for 1952 has been awarded to Dr. S. Chandrasekhar of the Yerkes Observatory, University of Chicago. This medal is awarded not oftener than once a year to an astronomer chosen for his distinguished services to astronomy. The first award was made in 1898.

Dr. Chandrasekhar was born in Lahore, India. He studied at Madras and at Cambridge, England, where he became acquainted with Eddington, Milne, Fowler, Rutherford, Dirac, and other theoretical physicists and astrophysicists. When he came to the United States he spent a short time at Harvard and then joined the staff of the Yerkes Observatory where he now holds the position of Distinguished Service Professor of Theoretical Astrophysics. He is noted for his theoretical work, covering such fields as stellar interiors and atmospheres and stellar motions and the dynamical properties of clusters and galaxies.

R.J.N.

New General Catalogue of Radial Velocities

Since 1932, when the last comprehensive catalogue of radial velocities was published by the late J. H. Moore of the Lick Observatory, there has been a vast accumulation of stellar radial velocities. A revision of this catalogue had been planned by Dr. Moore, and the work was eventually turned over to Dr. Ralph E. Wilson of Mount Wilson Observatory. Financial support for the publication was secured from the Carnegie Institution of Washington. The International Astronomical Union approved the plan at its meeting at Zurich in 1948.

The catalogue contains radial velocities for 15,100 stars, over twice the number of stars in Moore's catalogue. The three Canadian observatories have made a worth-while contribution in this field and have contributed over one-third of the number of velocities. Since the present trend in observing programmes seems to be away from stellar motions to a more detailed study of stellar atmospheres, this catalogue should be useful for many years.

R.J.N.

Death of C. O. Lampland

Dr. Carl O. Lampland, assistant director of the Lowell Observatory, died at Flagstaff, Arizona, on December 14, 1951, at the age of 78. He will always be remembered for his investigations of the principal planets, and in particular for his determination of the temperatures of the planets, done in collaboration with W. W. Coblentz. At the time of his death he was working on the improvement of the orbit of Pluto in co-operation with Yale and the U.S. Naval Observatory.

C.A.C.

Death of Bernard Lyot

Bernard Lyot, of the Pic du Midi Observatory in the Pyrenees, died on April 1, 1952, at the age of 55. At the time of his death he was in Cairo, Egypt, returning from observing the solar eclipse of February 25 from Khartoum, Anglo-Egyptian Sudan. He is well known for his development of the coronograph; his ingenuity in experimental techniques was outstanding.

C.A.C.

Variable Star Notes

"Variable Star Notes" from the American Association of Variable Star Observers will appear in this Journal commencing with the July-August issue. These observations had previously been reported in *Popular Astronomy*. The Editors welcome this new section in the Journal.

METEOR NEWS

By Peter M. Millman, *Dominion Observatory, Ottawa*

Photographic Meteor Spectra

Since 1930, except for six war years, I have been engaged in programmes of meteor photography; first at the Harvard Observatory, then at the David Dunlap Observatory, and most recently at the Dominion Observatory, Ottawa. In these programmes a special effort was made to secure meteor spectra since, prior to 1930, a world-wide total of only 8 spectra worth analysis had been secured. This number has gradually been increased until now over 120 have been photographed.

In the study of meteor spectra it has been found convenient to refer to each spectrum by a serial number. In previous issues of Meteor News an attempt was made to keep the world total of meteor spectra up to date by publishing yearly lists,[1] and assigning serial numbers. It was hoped that those knowing of additional examples would communicate with the writer. The last list appeared in 1940.

A complete list, including the previous lists and all other photographic meteor spectra I have knowledge of, is here reproduced in a table. In the first column will be found the assigned serial number. This is followed by the Greenwich date and time of the meteor. Where only the exposure times are known the mid-exposure time is indicated by an asterisk. If the meteor was a member of a recognized shower, this is indicated by an abbreviation. Next are listed the place where the photograph was taken and the observatory responsible for the programme. Finally, in the last column, is a reference to the most recent publication on the spectrum.

In 1949 a paper[2] summarizing preliminary results from 100 spectra was presented at the 81st Meeting of the American Astronomical Society in Ottawa. Compilation of all information derived from the study of meteor spectra is now being actively carried out at the Dominion Observatory. I would very much appreciate it if those knowing of spectra not included in this table would communicate with me at the Dominion Observatory, giving the tabular data for the additional spectra.

LIST OF PHOTOGRAPHIC METEOR SPECTRA (1897–1950)

No.	Date			G.C.T.			Shower	Location (Observatory)	Ref.
	y	m	d	h	m	s			
1	1897	6	19	4	25	*		Arequipa, Peru (H.C.O.)	3
2	1904	5	11	22	06			Moscow, U.S.S.R. (Moscow)	3
3		8	12	22	36		P	" " "	3
4	1907	8	12	17	42		P	" " "	3
5	1909	5	19	4	24	*		Arequipa, Peru (H.C.O.)	3
6	1920	8	11	10	31	*	P	Mt. Wilson, Calif. (Mt. W.)	3
7	1924	3	8	6	24			" " "	3
8	1924	9	29	20	17	*		Bergedorf, Germany (Hamburg)	3
9	1931	12	15	7	52			Blue Hill, Mass. (H.C.O.)	3
10		12	13	3	27		G	" " "	4
11	1913	1	9					Cambridge, Mass. (H.C.O.)	
12	1932	4	29	7	53	36		Flagstaff, Ariz. (H.C.O.)	4
13		5	26	7	15	04		" " "	4
14		5	27	8	18	19		" " "	4
15		11	16	5	59	44	L	Oak Ridge, Mass. (H.C.O.)	4
16		11	16	7	01	10	L	" " "	4
17		11	16	7	34	58	L	" " "	4
18		11	16	8	13	14	L	" " "	4
19		11	16	9	04	53	L	" " "	4
20		11	16	11	45		L	Fort Worth, Texas (Texas Obs.)	4
21		11	17	10	50		L	Flagstaff, Ariz. (H.C.O.)	4
22		11	17	12	50		L	" " "	4
23	1933	2	22	11	43	23		" " "	4
24		2	27	6	35	23		" " "	4
25		4	21	9	27			Fort Worth, Texas (Texas Obs.)	
26		8	12	7	03			" " "	
27		11	15	6	33		L	Franklin, Ky. (L. J. Wilson)	
28		11	15				L	Flagstaff, Ariz. (Lowell)	5
29		11	17	9	48		L	Blue Hill, Mass. (H.C.O.)	
30	1934	8	5	4	58			Fort Worth, Texas (Texas Obs.)	
31		8	12	6	22		P	Richmond Hill, Ont. (D.D.O.)	
32		8	12	7	30			Table Mt., Calif. (Pomona C.)	6
33		8	12	9	08		P	Fort Worth, Texas (Texas Obs.)	
34		8	12	9	34		P	" " "	
35		8	12	22	20		P	Moscow, U.S.S.R. (V.A.G.O.)	7
36		8	13	8	18		P	Richmond Hill, Ont. (D.D.O.)	
37		8	13	8	41		P	" " "	
38		12	14	5	09	*	G	N. Toronto (D.D.O.)	
39	1935	11	18	6	47	40		Richmond Hill, Ont. (D.D.O.)	8
40	1936	8	9					Apscheron, U.S.S.R. (Moscow)	
41		8	16					Apscheron, U.S.S.R. (Moscow)	
42		10	19	20	50			Upsala, Sweden (Upsala)	9
43	1937	8	4					Kutschino, U.S.S.R. (Kutschino)	
44		8	13	5	38	11	P	Richmond Hill, Ont. (D.D.O.)	
45		12	13	5	57	*	G	" " "	
46	1939	8	10	5	02		P	Ottawa, Ont. (D.O.)	10
47		8	12	5	42		P	Richmond Hill, Ont. (D.D.O.)	10
48		10	20	7	30		O	Charlottesville, Va. (Leander McC.)	11
49		11	16	8	20	16	L	Ottawa, Ont. (D.O.)	
50		12	12	4	42	*	G	Richmond Hill, Ont. (D.D.O.)	

LIST OF PHOTOGRAPHIC METEOR SPECTRA (*continued*)

No.	Date			G.C.T.			Shower	Location (Observatory)	Ref.
	y	m	d	h	m	s			
51	1939	12					G	Fort Worth, Texas (Texas Obs.)	
52		6	29	08	00			Mt. Wilson, Calif. (Mt. W.)	
53		9	19	20	58	18		Stalinabad, U.S.S.R. (Stalinabad)	12
54	1940	4	8	8	20			Mt. Palomar, Calif. (Mt. Palomar)	
55		8	10	5	28		P	Ottawa, Ont. (D.O.)	
56		8	10	8	40		P	Richmond Hill, Ont. (D.D.O.)	
57		8	11	4	50		P	" " "	13
58		8	11	8	47		P	Ottawa, Ont. (D.O.)	13
59		8	12	8	11		P	Richmond Hill, Ont. (D.D.O.)	
60		8	14	3	42		P	Ottawa, Ont., (D.O.)	
61	1941	8	13	4	50		P	Ottawa, Ont. (D.O.)	
62	1942	11	9	4	00			Mt. Palomar, Calif. (Mt. Palomar)	
63	1946	5	25	5	25			Mt. Wilson, Calif. (Mt. Wilson)	
64		8	12	7	22	30	P	Ottawa, Ont. (D.O.)	
65		8	12	8	35	37	P	" " "	
66		8	12	8	51	59	P	" " "	
67		10	10	2	26	30	J	North Bay, Ont. (D.O.)	14
68		10	10	2	42	00	J	" " "	14
69		10	10	2	46	00	J	" " "	14
70		10	10	2	35	42	J	" " "	14
71		10	10	2	47	36	J	North Bay, Ont. (D.O.)	14
72		10	10	2	56	48	J	" " "	14
73		10	10	3	10	30	J	" " "	14
74		10	10	3	11	36	J	" " "	14
75		10	10	3	31	54	J	" " "	14
76		10	10	3	28	24	J	" " "	14
77		10	10	3	22	06	J	" " "	14
78		10	10	3	22	30	J	" " "	14, 21
79		10	10	3	29	54	J	" " "	14
80		10	10	3	42	18	J	" " "	14
81		10	10	3	43	54	J	North Bay, Ont., (D.O.)	14
82		10	10	3	43	00	J	" " "	14
83		10	10	3	54	18	J	" " "	14
84		10	10	3	50	00	J	" " "	14
85		10	10	3	53	*	J	" " "	14
86		10	10	3	51	42	J	" " "	14, 21
87		10	10	4	17	06	J	" " "	14
88		10	10				J	Richmond Hill, Ont. (D.D.O.)	15
89		10	10	3	38	*	J	Nashville, Tenn. (L. J. Wilson)	
90		10	10	3	38	*	J	" " "	
91		10	10	3	50	*	J	Nashville, Tenn. (L. J. Wilson)	
92		10	10	3	50	*	J	" " "	
93	1947	10	6	2	40			" " "	
94		12	12	7	13			Mt. Palomar, Calif. (Mt. Palomar)	
95		12	12	8	28	38	G	Metcalfe Rd., Ont. (D.O.)	
96		12	13	9	25	15	G	" " "	
97		12	13	10	25	41	G	" " "	16
98		12	14	6	07	07	G	" " "	
99		12	14	6	07		G	Mt. Palomar, Calif. (Mt. Palomar)	
100	1948	8	5	5	33	20	P	Metcalfe Rd., Ont. (D.O.)	

LIST OF PHOTOGRAPHIC METEOR SPECTRA (*contined*)

No.	Date			G.C.T.			Shower	Location (Observatory)	Ref.
	y	m	d	h	m	s			
101	1948	8	9	5	46	57	P	Metcalfe Rd., Ont. (D.O.)	
102		8	10	3	35	39		Cambridge, Mass. (H.C.O.)	
103		8	12	6	08		P	Blairsden, Calif. (U.S.C.)	17
104		12	11	10	08	20	G	Metcalfe Rd., Ont. (D.O.)	
105	1949	7	28	5	20	47	D	" " "	21
106		8	13	3	19	55	P	" " "	18, 21
107		8	13	9	23	*	P	Blairsden, Calif. (U.S.C.)	19
108		12	14	0	28	42	G	Metcalfe Rd., Ont. (D.O.)	
109	1950	8	9				P	Simferopol, U.S.S.R. (V.A.G.O.)	20
110		8	12	2	45	17	P	Metcalfe Rd., Ont. (D.O.)	21
111		8	12	4	02	40	P	Metcalfe Rd., Ont. (D.O.)	
112		8	12	6	29	43	P	" " "	
113		8	13	5	21	46		" " "	
114		8	13	6	58	05	P	" " "	
115		8	14	3	02	23	P	" " "	
116		8	14	8	07	14	P	" " "	
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118		8						Blairsden, Calif. (U.S.C.)	
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120		8						" " "	
121		8						Blairsden, Calif. (U.S.C.)	
122		8						" " "	

Abbreviations—

D	Delta Aquarid	D.D.O.	David Dunlap Observatory
G	Geminid	D.O.	Dominion Observatory
J	Giacobinid	H.C.O.	Harvard College Observatory
L	Leonid	U.S.C.	University of Southern California
O	Orionid	V.A.G.O.	All-Union Astro-Geodetic Society
P	Perseid		

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MEETINGS OF THE SOCIETY

AT OTTAWA

March 3, 1951—The meeting was held in the National Museum, jointly with the local branch of the Engineering Institute of Canada. Dr. H. C. van de Hulst of Leyden spoke on "Radio Astronomy." The advantages which radio telescopes have over ordinary ones were described, and the efforts made to improve their resolving power. The impetus given to radio astronomy by wartime advances in radar techniques was noted, and the work being done by the National Research Council on the sun and meteors. Studies of the temperature of the moon's surface and of the sun's corona were described. Radio telescopes penetrate the obscuring clouds of the Milky Way to the galaxy's centre, and have probed into space to examine extra-galactic nebulae. They may even help settle questions of the extent and structure of the universe. B. G. Ballard of the Institute thanked the speaker.

March 30, 1951—A regular meeting held at the Museum heard Dr. T. W. Straker of the Radio Physics Laboratory of the Defence Research Board speak on "Effects of the Sun on Radio Transmission." The structure of the ionosphere and its action on radio waves were described. Radio studies extend and supplement our knowledge of the upper atmosphere. The sun is mainly responsible for control of the ionosphere, which is maintained by the sun's ultra-violet light; streams of ionized particles from the sun are connected with such phenomena as the aurora, magnetic storms and radio blackouts. Canada being in the auroral zone, ionospheric storms are of great interest to us. The close connection of radio work on the ionosphere with the astronomer's study of flares and sun-spots was made evident in discussing the problems of forecasting radio transmission conditions. Questions from the floor at the end of the lecture showed its interest for the audience, on whose behalf A. E. Covington thanked Dr. Straker.

April 13, 1951—The spring season concluded with a Members' Night in the Museum. This took the form of a discussion of variable stars under the chairmanship of Walter Stilwell. Jack Grant of the Dominion Observatory outlined briefly the classification of these stars and then described the contribution of the amateur to their study. The A.A.V.S.O. programme was explained, and the work of such

observers as Bryden, Garneau, Topham, Williamson, and Nadeau was set out as examples. Stanley Mott took up the story of the Cepheids. Slides illustrated the characteristics of Cepheid variation, and the relation of brightness to radial velocity. The use of the period-luminosity relation as a yardstick was described. Next J. E. Lilly spoke on the Algol-type variable, demonstrating the eclipses with the aid of a model double star. The short career of Goodricke, who did his work on Algol at the age of 18, was reviewed. These variables are the source of much of our information about stars, and over a thousand are catalogued, with periods ranging from 5 hours to 27 years. F. W. Matley in conclusion discussed those cataclysmic variables, the novae. He told of the amazing flare-up in brightness in a few days characteristic of these stars, and of the still greater outbursts of the rarer super-novae. Two theories of the mechanism of these explosions were examined, and their interest for nuclear research and cosmology was stressed. In thanking the speakers for the presentation, Dr. Millman spoke of the value of such discussions in arousing interest among our members, many of whom were non-professional, rather than amateur, astronomers.

December 6, 1951—The annual dinner meeting of the Ottawa Centre was held at the cafeteria of the Experimental Farm at 6.30 p.m. Ninety members and friends attended. The business meeting was opened at 8.30 by W./Cdr. MacLulich. J. M. Robinson and Miss M. S. Burland, scrutineers, reported the results of balloting for the 1952 executive.

Thanks were expressed to the National Museum and the National Research Council for the use of their auditoriums for meetings, and to the director of the Experimental Farm for facilities for the present meeting.

Dr. MacLulich outlined a programme of four meetings for the coming season. The treasurer's and secretary's reports for 1951 were read and adopted.

Following the business meeting, the Centre was entertained by a quartet: P. H. Serson, Friedrich Bender, Mrs. A. E. Covington, and F. P. Lossing, who played Mozart's Dissonance quartet. Dr. C. S. Beals thanked them on behalf of the audience.

The speaker of the evening was R. Meldrum Stewart, former Dominion Astronomer, and our honorary president, who spoke on "Canadian Astronomical History." Mr. Stewart is well qualified to speak on this subject, having devoted 44 years to astronomy in the public service.

He began by sketching the history of the Royal Astronomical Society of Canada, as it now is called, and paid tribute to its part in the development of astronomy in Canada. The careers of W. F. King and Otto Klotz were followed next, as astronomy progressed from a mere adjunct to surveying and time-keeping to its present flourishing state. The early work of the Dominion Observatory was described, and illustrated with numerous slides.

The story of the Dominion Astrophysical Observatory in Victoria under Plaskett, Harper, and Pearce was traced; then that of the David Dunlap Observatory. Mr. Stewart mentioned how much Canadian astronomy owes to Dr. Chant as teacher and organizer. Other Canadian observatories were noted briefly, down to the latest meteor station at Meanook, Alberta.

In conclusion, a thirty-year-old film made at the Dominion Observatory was shown, which aroused both interest and laughter.

Dr. Ernest Hodgson thanked the speaker for his address, and drew attention to Mr. Stewart's contributions to the history, both in his own scientific work and in the close interest with which he followed every problem at the Dominion Observatory during his long directorship.

R. W. Tanner, *Secretary.*

AT TORONTO

November 27, 1951—The meeting was held in the McLennan Physics Laboratory, with the President, Mr. F. L. Troyer, in the chair.

Three new members were elected to the Society:

T. L. Derwent Kinton, M.A., 433 Durie St.

Charles A. Shearson, M.A., R.R. 2, Aurora.

Kenneth G. Wakefield, 105 North Bonnington Ave., Scarboro Junction.

The report of the Nominating Committee was given.

Dr. J. F. Heard gave a very satisfactory report on the Frank S. Hogg Memorial Fund. Over $7,000 of the objective of $10,000 has been received and it is hoped that before long the University will be announcing the conditions of the award.

The speaker of the evening, Dr. Helen Hogg, spoke on "Marvels of the Milky Way," choosing for specific reference five of the most important developments in astronomy during the past decade. These were: 1. Ten years ago the amount of obscuring interstellar matter was considered insignificant. Now it is believed that the total mass of interstellar material is equal to that of all the stars. 2. Stars have been divided into types of stellar populations. It has been found that certain aggregations have qualities that others have not. 3. In the past ten years the Hale 200-inch telescope has been completed and put into operation. 4. The Schmidt telescope has been developed and is proving to be a very powerful instrument, particularly in the work of surveying. 5. Deep red plates in photography have been perfected and are in increasing demand.

Mrs. Hogg illustrated these points with many interesting slides showing both pictures and charts. Many recent theories were included in this talk, such as the possibility of the Crab Nebula being the result of a supernova and that the distribution of the galactic clusters near the centre of the Milky Way indicates they might be in the arms of a spiral nebula. Mrs. Hogg also showed slides of globular clusters and explained the part played by Cepheid variables in obtaining their distances.

Dr. Heard moved the motion by Mr. Troyer that a letter of condolence be sent to Dr. Ralph DeLury, brother of the late Prof. DeLury, the oldest life member of the Society.

BARBARA CREEPER, *Recorder pro tem.*

AT MONTREAL

January 25, 1951.—The meeting was held at Macdonald Physics Building, McGill University, on Thursday, January 25, 1951, at 8.15 p.m. The President, Miss I. K. Williamson, was in the Chair. 113 members and visitors were present.

It was announced that, weather permitting, the occultation of Venus on the evening of February 7th would be observed, the arrangements for this to be made by Mr. W. H. Birtles.

The Handbook talk for the evening followed, given by Mr. T. Noseworthy on "Configuration of Jupiter's satellites".

The speaker of the evening was Dr. A. Vibert Douglas, formerly of the staff of McGill University, now of Kingston, Ont., who has had a long and intimate connection with the Centre. She gave as her subject, "Half a Century of Astronomy". Dr. Douglas briefly surveyed the amazing progress in various branches of science since 1900, discussing the studies of atomic structure, the theories of relativity, the development of non-Euclidean geometry, and the new ideas in physics and geometry. The new telescopes and other new kinds of instruments developed in these latter years enabled special studies in many branches of astronomy to be made, notably detailed

studies of the solar gases, planetary and cometary atmospheres, matter in interstellar space, the source of stellar energy, the constitution of the stars and the red shift of spiral galaxies which resulted in the theories of expanding space developed by Abbe Lemaitre and Eddington. In closing, Dr. Douglas eulogized the work and character of Eddington, quoting the opinions of leading scientists, who, at his death, declared Eddington to be the greatest astronomer of this period. Dean Hall tendered to Dr. Douglas the thanks of the Centre.

February 8, 1951.—The meeting was held at Macdonald Physics Building, McGill University, on Thursday, February 8, at 8.15 p.m. The President, Miss I. K. Williamson, was in the Chair. 43 members and visitors were present. It was moved by Mr. Birtles, seconded by Mr. DeKinder, that the following be admitted to membership: Mr. Donald Frappier and Misses Dorothy Heyworth and Gladys James.

The Handbook talk followed, given by Miss I. K. Williamson, on the "Minima of Algol".

The programme for the evening, a symposium of four short talks, followed: Mr. DeLisle Garneau, "The Sun"; Mr. Bryan Cockhill, "The Inner Planets"; Mr. W. H. Birtles, "The Outer Planets"; Mr. A. R. McLennan, "Between the Planets".

E. E. Bridgen, *Recording Secretary.*

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